U.S. Army Environmental Center

Final Record of Decision/ Remedial Action Plan Nine Sites Sierra Army Depot Lassen County, California

Prepared by:

Harding Lawson Associates
707 Seventeenth Street
Suite 2400
Denver, Colorado 80202

In conjunction with:

Montgomery Watson
365 Lennon Lane
Walnut Creek, California 94598

October 1996

Prepared for:
U.S. Army Environmental Center
Aberdeen Proving Ground, MD 21010-5401

Contract No. DACA 31-94-D-0069
Delivery Order No. 0005

Printed on Recycled Paper

TOTAL ENVIRONMENTAL PROGRAM SUPPORT

Final Record of Decision/Remedial Action Plan Nine Sites Sierra Army Depot Lassen County, California

Prepared for

U.S. Army Environmental Center
Building E4480 (Edgewood Area)
Aberdeen Proving Ground, Maryland 20101

HLA Project No. 12299 14.02.00

October 1, 1996

Harding Lawson Associates
Engineering and Environmental Services
707 Seventeenth Street, Suite 2400
Denver, CO 80202 - (303) 292-5365

IN ACCORDANCE WITH ARMY REGULATION 200-2, THIS DOCUMENT IS INTENDED BY THE ARMY TO COMPLY WITH THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969.

THE INFORMATION AND CONCLUSIONS PRESENTED IN THIS REPORT REPRESENT THE OFFICIAL POSITION OF THE DEPARTMENT OF THE ARMY UNLESS EXPRESSLY MODIFIED BY A SUBSEQUENT DOCUMENT. THIS REPORT CONSTITUTES THE RELEVANT PORTION OF THE ADMINISTRATIVE RECORD FOR THIS OPERABLE UNIT.

THE USE OF TRADE NAMES IN THIS REPORT DOES NOT CONSTITUTE AN OFFICIAL ENDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL PRODUCTS. THE REPORT MAY NOT BE CITED FOR PURPOSES OF ADVERTISEMENT.

SIERRA ARMY DEPOT
RECORD OF DECISION/REMEDIAL ACTION PLAN

AMMUNITION DEMILITARIZATION AND RENOVATION AREA
BUILDING 1003 AREA
CHEMICAL BURIAL SITE
CONSTRUCTION DEBRIS LANDFILL
EXISTING LANDFILL
EXISTING POPPING FURNACE
LARGE SEWAGE TREATMENT PONDS
LOWER BURNING GROUND
1960 DEMOLITION AREA

Donald D. Whitfield, II
Colonel, OD
Commander
Sierra Army Depot

9 Jun 96
Date

Billy K. Solomon
Major General, U.S. Army
Chief of Staff
U.S. Army Materiel Command

25 Sep 96
Date

Anthony J. Landis, P.E.
Chief of Regional Operations
Office of Military Facilities
California Department of Toxic Substances Control

October 1, 1996
Date

Harold Singer
Executive Officer
California Regional Water Quality Control Board
Lahontan Region

Sep 27, 1996
Date

TOTAL ENVIRONMENTAL PROGRAM SUPPORT

Final Record of Decision/Remedial Action Plan Nine Sites Sierra Army Depot Lassen County, California

Report Preparation Team

Shari L. Arroyo
Anita M. Larson
Michelle M. Parent
Juliana M. Silvers
Paul H. Weaverling
Jerry T. Wickham

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

This Record of Decision (ROD)/Remedial Action Plan (RAP) has been prepared by Harding Lawson Associates (HLA) and Montgomery Watson for the U.S. Army Environmental Center (USAEC), under the Total Environmental Program Support (TEPS) Contract.

1.1 Site Names and Locations

This ROD/RAP addresses nine sites at Sierra Army Depot (SIAD), Lassen County, California. These nine sites and the selected remedy for each site include the following:

- Ammunition Demilitarization and Renovation Area - No Action
- Building 1003 Area - Excavation and offsite asphalt incorporation of petroleum hydrocarbon impacted soil
- Chemical Burial Site (subsite of the Construction Debris Landfill) - No Action
- Construction Debris Landfill - No Action
- Existing Landfill - No Action, regulated as Subtitle D facility under the Resource Conservation and Recovery Act (RCRA)
- Existing Popping Furnace (in Building P556 near the trinitrotoluene [TNT] Leaching Beds Site) - No Action, regulated under RCRA
- Large Sewage Treatment Ponds - Excavation and offsite disposal of polychlorinated biphenyl (PCB)-contaminated soil
- Lower Burning Ground - No Action, deed and access restrictions due to potential unexploded ordnance
- 1960 Demolition Area - No Action, deed and access restrictions due to potential unexploded ordnance

The locations of these sites are shown in Figure 1.1.

1.2 Statement of Basis and Purpose

This ROD/RAP presents the selected response actions for nine sites at SIAD. The response actions were selected by the U.S. Department of the Army (Army) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments Reauthorization Act of 1986 (SARA)(collectively referred to as CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and Section 6.8 of the California Health and Safety Code. This ROD/RAP includes the factual and legal basis for selecting the response action at each of the nine sites listed above. The data used to support the selected response

action are contained in the Administrative Record for each site. The State of California as represented by the Department of Toxic Substances Control (DTSC), and the Lahontan Regional Water Quality Control Board (RWQCB) concur with the selected response action at each site.

As set forth in Section 25356.1(d) of the California Health and Safety Code, a RAP approved by DTSC must include a non-binding, preliminary allocation of financial responsibility among all identifiable potentially responsible parties. DTSC has reviewed the relevant evidence and concluded that the preliminary non-binding allocation of financial responsibility for the sites incorporated in this ROD/RAP is as follows:

- U.S. Army, Sierra Army Depot 100 percent

1.3 Site Background Information

This section provides a description and history of SIAD.

1.3.1 Sierra Army Depot Site Description

SIAD is located in the Honey Lake Valley of Lassen County in northeastern California (Figure 1.2). The installation is located approximately 3 miles northeast of U.S. Highway 395 and 4 miles west of the California-Nevada state border. Susanville, California (40 miles to the northwest), and Reno, Nevada (50 miles to the southeast), are the nearest large cities to SIAD. Nearby communities include Herlong, and Sage Flats, California. Herlong is situated on the installation along its southern border. Sage Flats is outside the main gate to SIAD, on the south side of the installation.

SIAD is divided into two sections: the Main Depot and the Upper Burning Ground (Figure 1.2). The Main Depot covers 33,163 acres (approximately 52 square miles). The sites included in this ROD/RAP are located on the Main Depot. The Main Depot's surface elevation varies from approximately 4,000 to 4,130 feet above mean sea level, showing little topographic relief.

Honey Lake, west of the Main Depot, covers approximately 60,524 acres (95 square miles) and occupies the lower part of Honey Lake Valley. Honey Lake is included in the SIAD boundary. In

1977, 60,106 acres of the lake were offered on a Quit Claim Deed to the State of California. The offer was not accepted.

The Honey Lake Valley is located in the Basin and Range physiographic province. This area is characterized by northwest trending block-faulted mountains and valleys. The valley is bordered by the Shaffer and Antelope mountains to the north, the Skedaddle and Amedee mountains to the northeast, the Fort Sage and Virginia mountains to the southeast, and the Diamond Mountains to the south and southwest.

1.3.1.1 Meteorology

Honey Lake Valley has an arid climate characterized by low relative humidity and low precipitation. The average summer temperature is approximately 68 degrees Fahrenheit (°F) and the average winter temperature is approximately 35°F (JMM and ECJ, 1991).

The annual mean precipitation at SIAD is 5.6 inches with approximately half of the precipitation occurring as snow during the winter (USATHAMA, 1979). The annual mean precipitation in the mountains surrounding SIAD is approximately four times the amount that the valley floor receives (ESE, 1983).

The prevailing wind direction ranges from the south to the northwest with an average wind speed of approximately 6 miles per hour (USATHAMA, 1979).

1.3.1.2 Surface-Water Hydrology

The most prominent surface-water feature in Honey Lake Valley is Honey Lake. Honey Lake is a shallow basin that fluctuates greatly in area and volume in response to recharge from precipitation and runoff. On average, Honey Lake has a surface area of approximately 73 square miles (Handman et al., 1990). Several smaller lakes and reservoirs are also present in the Honey Lake Valley.

Main surface drainages from the surrounding mountain ranges include the Susan River to the northwest, Baxter Creek to the northeast, and Long Valley Creek to the southeast of SIAD (Benioff et al., 1988). These streams and rivers, excluding the Susan River, are considered ephemeral. The

Honey Lake Valley appears to be isolated because no surface water flows from the valley. The United States Geological Survey (USGS) topographic quadrangle maps containing SIAD indicate that no main surface drainages cross the Main Depot. Occasional springs and surface seeps are evident adjacent to mountain ranges on area topographic maps (USGS, 1988a, 1988b, 1988c, and 1988d). Water from Amedee Hot Springs reportedly forms a permanent wetland of about 200 acres to the northwest of the Main Depot on the northeast side of Honey Lake (J. Colberg, oral commun., 1993).

1.3.1.3 Geology

The geologic history of the Honey Lake Valley is characterized by Tertiary block-faulting, volcanism, and basin-fill sedimentation. A major regional structural feature of probable mid-Miocene origin known as the Walker Lane fault system extends into Honey Lake Valley from the southeast. This fault system exerted primary control on the Tertiary basin-fill sedimentation in the Honey Lake Valley and the development of its present day topographic features.

Granitic rocks of late Mesozoic origin are present in the Diamond Mountains south of SIAD and are believed to lie beneath the basin-fill Tertiary sedimentary deposits and volcanic rocks (Handman et al., 1990). Miocene and Pleistocene volcanic rocks overlie the granitic basement in the eastern and northern mountain ranges of the Honey Lake Valley. The basin-fill sequence of Honey Lake Valley is comprised of Pliocene to Holocene unconsolidated and semiconsolidated sediment and pyroclastic rock. Figure 1.3 illustrates the stratigraphic column in the Honey Lake vicinity (California Department of Water Resources [DWR], 1963). A geologic cross section (Figure 1.4) from Handman et al., (1990), illustrates the generalized stratigraphic relationships that comprise the Honey Lake vicinity.

The basin-fill deposits beneath SIAD consist of unconsolidated and semiconsolidated lacustrine and fluvial deposits of clay, silt, sand, and gravel. The distal lake sediments and proximal alluvial fan deposits are characterized by a transgressive-regressive migrating shoreface that resulted in an interfingering of fine- and coarse-grained deposits in the sedimentary basin fill. This depositional environment displays rapid facies changes over short distances and is interbedded with Pliocene and Pleistocene basalts and pyroclastics.

During recent environmental studies, numerous soil borings have been drilled and monitoring wells have been installed throughout the Main Depot. Lithologic logs for these borings indicate that the northern half of the Main Depot is underlain predominantly by clays and silts with thin sand interbeds to a depth of 250 feet below ground surface (bgs) (JMM and ECJ, 1991). The southern half of SIAD is underlain predominately by sand in this interval with occasional thin interbeds of clay and silt.

1.3.1.4 Hydrogeology

The relatively thick, unconsolidated and semiconsolidated Pliocene to Pleistocene basin-fill deposits provide the principal water-bearing formations in the Honey Lake Valley (Figure 1.3). Beneath SIAD, the water-bearing zones encountered in monitoring wells and Potable Supply Wells are interpreted to consist of Lahontan Lake deposits. Recharge to the basin-fill deposits originates primarily as infiltration of precipitation in upland areas and infiltration of stream flow in alluvial fan areas (Handman et al., 1990). Discharge from the aquifers within the basin-fill deposits is likely to occur at Honey Lake. Discharge also occurs from irrigation and water-supply wells in the valley.

The hydraulic conductivity of the unconsolidated sediment generally decreases with decreasing elevation. The median hydraulic conductivity of the basin-fill deposits and volcanic rocks has been estimated to be approximately 8 feet per day (3×10^{-3} centimeters per second [cm/s]) on the basis of production tests of supply wells and descriptions of geologic materials that occur in the basin (Handman et al., 1990).

Depth to groundwater varies widely over the Main Depot. The depth to water adjacent to Honey Lake is less than 3 feet, but the depth to groundwater is approximately 120 feet near the southern end of the Main Depot in the vicinity of the four Potable Supply Wells for SIAD. The southern portion of SIAD lies on a sand terrace and is slightly higher in elevation than the northern portion of the installation.

Figure 1.5 indicates that groundwater flow is generally to the north in the southern portion of the Main Depot and to the southwest and west in the northern portion of the Main Depot. The western

portion of the Main Depot is characterized by a relatively flat hydraulic gradient with westward groundwater flow. Regional water-level data indicate that groundwater flow in the central portion of Honey Lake Valley east of the Main Depot is to the east (California DWR, 1963; Handman et al., 1990). Eastward groundwater flow is evident in the southeast portion of the Main Depot.

Two groundwater mounds are present in the southern portion of the Main Depot. These two groundwater mounds form a local groundwater divide from which groundwater flows north and south at the southern end of the Main Depot.

Local variation in the piezometric surface may also occur in the vicinity of groundwater supply wells at SIAD (USAEHA, 1972; ESE, 1983; Benioff et al., 1988). The four current SIAD Potable Supply Wells located in the southern portion of the Main Depot (Figure 1.1) may cause seasonal variations in groundwater flow direction because of the variation in pumping during the wet and dry seasons. Water-supply wells used for irrigation between the Main Depot and the Upper Burning Ground may cause variation in groundwater flow direction; however, this variation has not been documented (ESE, 1983).

1.3.1.5 Demography and Land Use

SIAD is located in a sparsely populated area of northeast California. There are no major cities in the region and few towns exist in the vicinity of SIAD (Figure 1.2). Approximately 1,000 people reside in the communities of Herlong and Sage Flats, which are located at the southern entrance to the Main Depot. The Main Depot has a current population of approximately 800 people including military personnel and their families. The town of Milford, located approximately 12 miles west of SIAD, has a population of 70 people, with an additional 300 people located in the surrounding area. Several hamlets are also scattered throughout the valley floor, each containing few domestic dwellings. The towns of Amedee and Wendel are located approximately 2 and 5 miles northwest of the Main Depot, respectively (Figure 1.2).

Lassen County has prepared a series of "area" plans covering selected portions of the county (Resource Concepts, Inc., 1987; Lassen County Planning Department, 1990). SIAD is located within

the Wendel Planning Area. Due to limited development and the sparse population, the basic land-use categories in this planning area include (1) grazing/open space, (2) military, (3) agricultural, (4) towns and urban reserve, and (5) wildlife areas.

The largest land-use category is grazing/open space and most of the land in this category is covered with native vegetation. A vast majority of this land is in public ownership, with some private lands included. Approximately one-third of the total Wendel Planning Area is devoted to military use (SIAD). Several parcels of land in the planning area are designated for agricultural purposes, although not all of this designated land is currently under cultivation. According to aerial photographs that cover the planning area (U.S. Fish and Wildlife Service [USFWS], 1989a, 1989b, 1989c, and 1989d), a few agricultural fields are present outside of the areas designated for agricultural use by the Lassen County Planning Department. Agricultural activity in the area around SIAD includes primarily hay production and cattle ranching. A potato farm is located northeast of the Main Depot, on the land that separates the Main Depot from the Upper Burning Ground. The fourth land use category, towns and urban reserve, consists of the towns of Wendel and Amedee located northwest of SIAD, and Herlong and Sage Flats located on the southern border of SIAD. A wintering habitat for mule deer and antelope is located just south of the southern boundary of SIAD in the Doyle State Wildlife Area.

1.3.1.6 Ecology

The ecological setting at SIAD is characterized by expansive areas dominated by shrubs and grasses typical of semidesert regions in the intermountain western United States. Greasewood (*Sarcobatus vermiculatus*) is the dominant vegetative cover in poorly drained, highly alkaline soil where the water table is near ground surface. Big sagebrush (*Artemisia tridentata*) and rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*) codominate in areas where soil is well drained. Saltgrass (*Distichlis stricta*) is the dominant plant species on seasonally flooded alkali flats including the dry lakebed of Honey Lake.

Several tree species have been introduced at SIAD for erosion control purposes, including Chinese elm (*Ulmus pumila*), Russian olive (*Elaeagnus angustifolia*), Engelmann spruce (*Picea engelmannii*),

ponderosa pine (*Pinus ponderosa*), junipers (*Juniperus* spp.), and cottonwoods (*Populus* spp.). Naturalized Chinese elm trees are sparsely distributed along water courses on and around SIAD.

Water from Amedee Hot Springs forms a permanent wetland of about 200 or more acres on the northeast side of Honey Lake (J. Colberg, oral commun., January, 1993). A wetland survey was conducted for SIAD in October 1995. The results of that survey were not available at the time that this ROD/RAP was prepared.

The following discussion of animal species known to occur on and near SIAD is summarized from the Sierra Army Depot Wildlife Management Plan (Colberg, 1992). There are approximately 349 different known species of birds, mammals, reptiles, amphibians, and fish at SIAD. Bird life is abundant because Honey Lake Valley is a major western flyway for migratory birds. Over 100 bird species including waterfowl, raptors, game birds, perching birds, and others are known to migrate through or inhabit SIAD.

Common large mammals known to inhabit the Honey Lake Valley include gray, red, and kit fox (*Urocyon cinereoargenteus, Vulpes fulva,* and *V. microtis*); coyote (*Canis latrans*); mountain lion (*Felis concolor*); bobcat (*Felis rufus*); pronghorn antelope (*Antilocapra americana*); mule deer (*Odocoileus hemionus*); and wild horse (*Equus caballus*). Small mammals inhabiting areas at SIAD include a variety of bats, rabbits, rodents, shrews, and small carnivores such as badger (*Taxidea taxus*), weasel (*Mustela frenata*), mink (*Mustela vison*), and skunk (*Mephitis mephitis*). Many species of reptiles and amphibians inhabit SIAD as well.

The water level of Honey Lake fluctuates from year to year depending upon the amount of regional precipitation. According to the Sierra Army Depot Wildlife Management Plan (Colberg, 1992), naturally occurring and stocked fish species that may be present in Honey Lake and its tributaries are largemouth bass (*Micropterus salmodes*), brown bullhead (*Ictaluras nebulosus*), black crappie (*Pomoxis nigromaculatus*), Sacramento perch (*Archoplitesa interruptus*), bluegill (*Lepomis macrochrus*), pumpkinseed sunfish (*Lepomus gibbosus*), tui chub (*Gila bicolor*), redside shiner (*Richardsonius*

egregius), catfish (*Ictalurus puncatus*), speckled dace (*Richimichthys osculus*), Tahoe sucker (*Catostomus tahoensis*), and mosquito fish (*Gambusia affinis*).

Two federally listed endangered avian species and three state-listed threatened avian species are known to occur or potentially occur near SIAD. The federally endangered bald eagle (*Haliaeetus leucocephalus*) and peregrine falcon (*Falco peregrinus*) (proposed for delisting) are frequent migrants that may use Honey Lake for feeding purposes. The greater sandhill crane (*Grus canadensis*), a state-listed threatened species, is known to migrate through the Honey Lake Valley. The state-listed threatened bank swallow (*Riparia riparia*) is included on the list of SIAD wildlife (Colberg, 1992). Bank swallows typically build nests or burrows in eroding river banks and coastal bluffs. A portion of the current population of bank swallows exists in widely scattered, generally small colonies in northern California (Steinhart, 1990). Swainson's hawk (*Buteo swainsoni*), listed by the State of California as threatened, has been observed at SIAD.

Additional plant and animal species that are federal candidate species, federal sensitive species, and California species of special concern are discussed in the Group III A Final Sites Remedial Investigation (RI) Report (HLA, 1994a).

1.3.2 Sierra Army Depot History

Honey Lake was acquired by the Army Air Corps in 1933 for use as an aerial bombing and gunnery range. In 1942, Sierra Ordnance Depot began operations as a reserve storage and supply depot for inert materials belonging to the U.S. Department of the Treasury. The Sierra Ordnance Depot was redesignated as the SIAD in 1962 because of the reorganization of the Army's Logistical Support Command under the Army Material Command.

During the 1940s, the Army Air Corps ceased its activities at Honey Lake; however, portions of the lakebed were used by the Sierra Ordnance Depot during the 1940s and 1950s as a demolition and function test range. Upon completion of the extensive Igloo Storage Area, the Sierra Ordnance Depot mission expanded to include storage of ammunition and explosives. In 1954, the function of

receiving, storing, and issuing guided missiles and propellant fuels was added. During the Vietnam War, SIAD was also used as a vehicle maintenance location.

The work force and activity at SIAD fluctuated with the involvement of the United States in military conflicts. Work force peaks were noted during the Korean Conflict and the Vietnam War. After the Vietnam War, the civilian work force was reduced when large-scale vehicle maintenance activities ceased.

The present mission of SIAD is the receipt, storage, surveillance, maintenance of munitions, strategic and critical material, and obligated war reserve material. To fulfill this mission, SIAD has a current population of approximately 800 personnel, including soldiers and their families. On February 28, 1995, the Secretary of Defense submitted a recommendation to Congress that SIAD be selected for major realignment under Public Law (P.L.) 100 to 526 and P.L. 101 to 510. In July of 1995, Congress and the President finalized the Base Realignment and Closure (BRAC) 95 list of base closures and realignments. SIAD, as part of the BRAC 1995 (BRAC 95) realignment bases, is undergoing transformation of missions and anticipates to release property for reuse in accordance with the Community Environmental Response Facilitation Act (CERFA). The SIAD parcels identified for reuse in 1995 are Honey Lake and an estimated 540 acres in the southwestern section of the main post.

Current and past operations at SIAD are as follows:

- Routine maintenance of depot equipment and vehicles
- Maintenance and renovation of munitions
- Demilitarization of munitions
- Aerial bombing and gunnery practice

Specific work practices involved with these operations include the following:

- Spray painting
- Welding and soldering
- Degreasing

- Lubricating
- Preserving with oils and waxes
- Removing rust and paint
- Explosive washout and destruction in popping furnaces
- Grinding and machining
- Abrasive blasting
- Packaging items (including explosives)
- Maintaining batteries
- Steam cleaning
- Heat-treating metal parts
- Handling asbestos and insecticides
- Explosive detonation and burning

1.4 Community Participation

The remedial investigation reports for the nine sites were released to the public beginning in 1990. Feasibility study reports for the Building 1003 Area and the Lower Burning Ground and the Large Sewage Treatment Ponds were finalized and released to the public in February 1996. Copies of these documents were placed in both the Administrative Record and at the following information repositories:

- Sierra Army Depot Library in Herlong, California
- Lassen County Free Library in Susanville, California

The public was informed of the availability of these documents by publishing a notice of availability in the *Lassen County Times* on February 7 and 14, 1996, in the *Reno Gazette Journal* on February 8 and 15, 1996, and on the Susanville Cable Television Public Announcement Bulletin on approximately February 8 and 15, 1996.

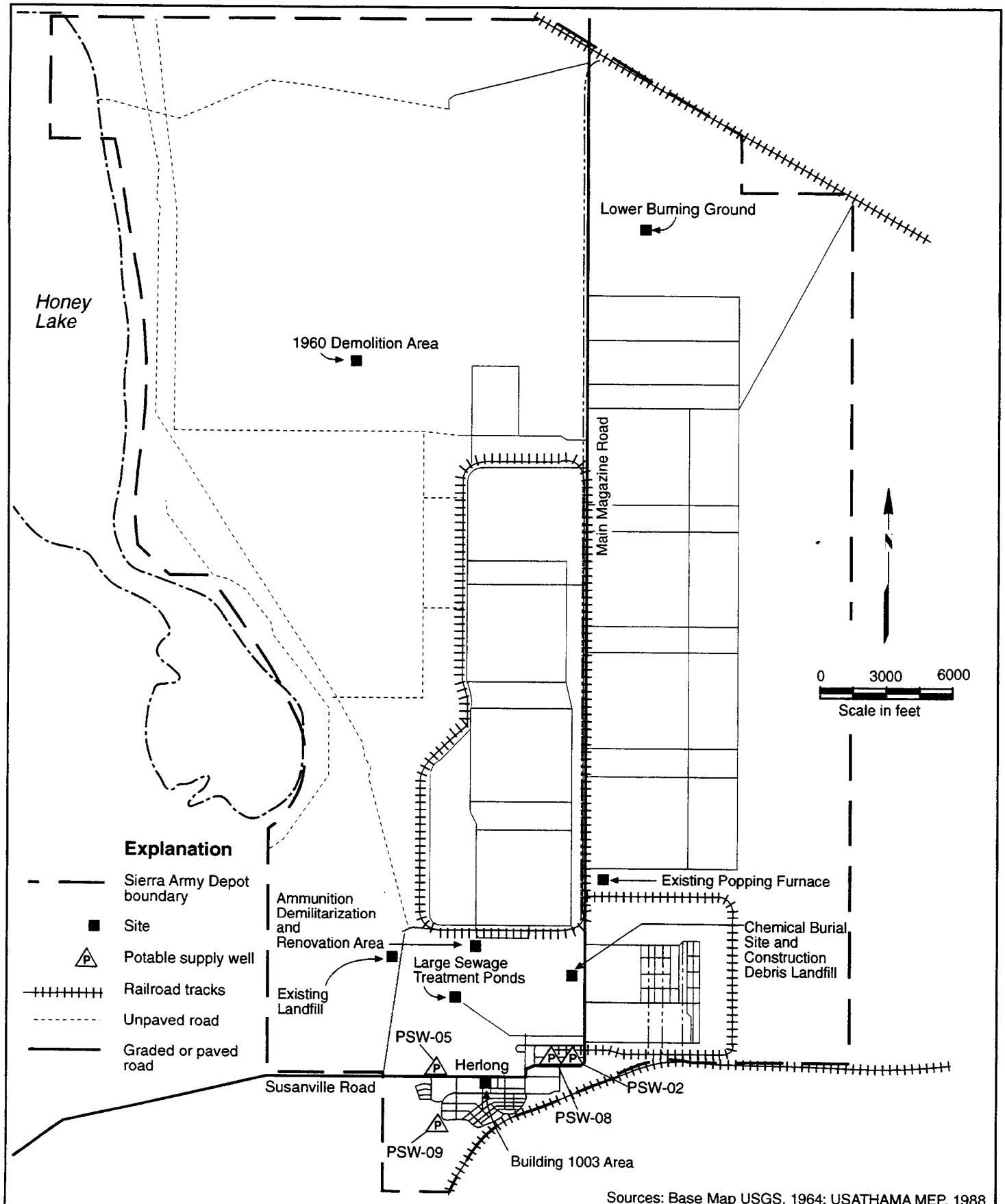
One 30-day public comment period was held from February 7, 1996, to March 7, 1996. A public meeting was held at SIAD on February 22, 1996. Representatives of the Army, DTSC, and Lahontan

RWQCB were present at the meeting. Responses to questions raised by the public at this meeting for a specific site are presented in the site-specific responsiveness summary.

The public participation requirements of CERCLA § 113(k)(2)(B)(i-v) and § 117 and § 25356.1 of the California Health and Safety Code were met in the remedy selection for each of the nine sites addressed herein. The response actions presented in this ROD/RAP were selected in accordance with CERCLA, NCP, Chapter 6.8 of the California Health and Safety Code, and the California Water Code. The basis for the respective response action selected at each site is documented in the Administrative Record.

1.5 Report Organization

The remaining sections of this ROD/RAP have been organized on a site-by-site basis. The discussion for each site follows a format consistent with the preferred alternative for that site as outlined in the Interim Final Guidance in Preparing Superfund Decision Documents (EPA, 1989a).



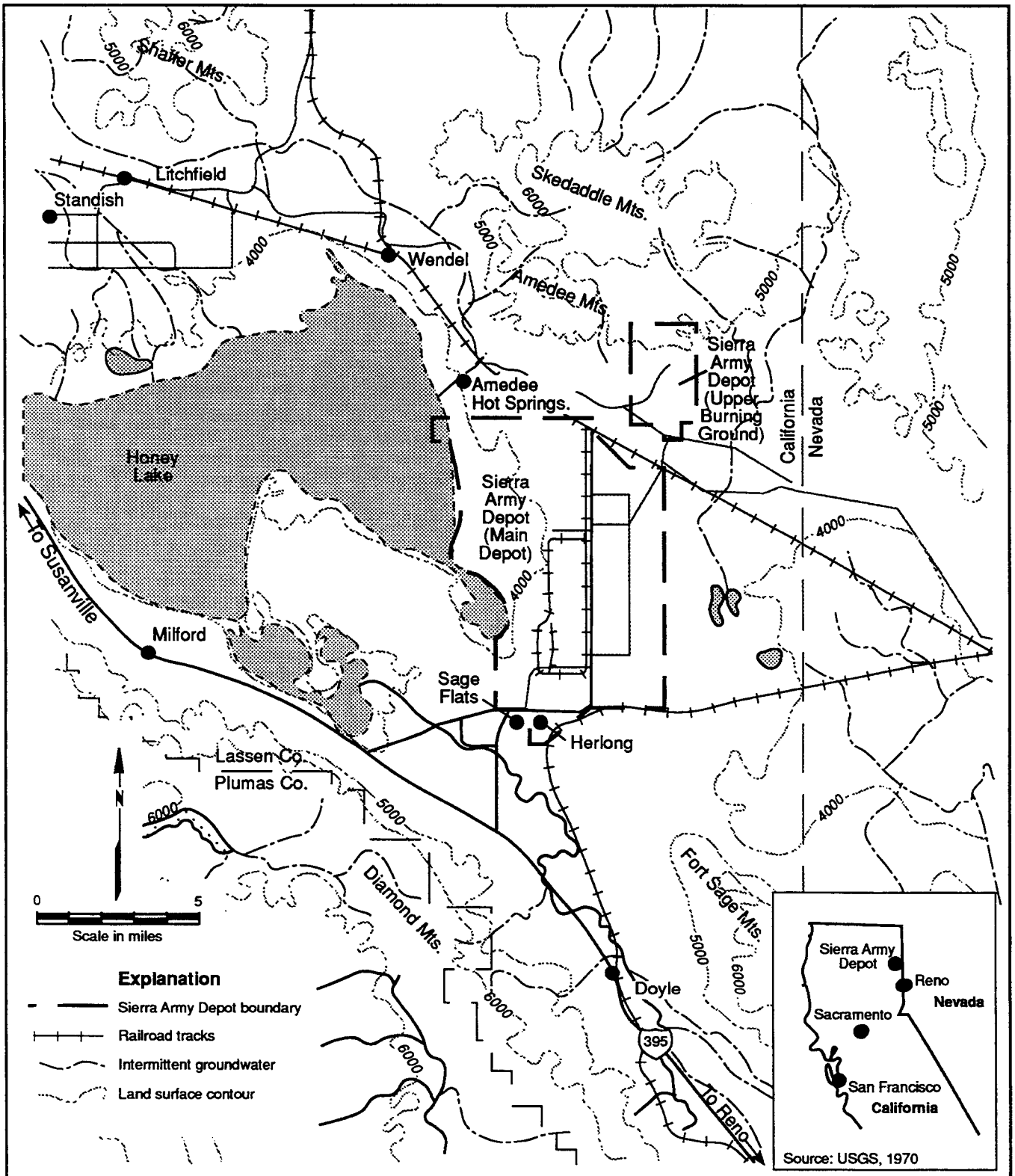
Harding Lawson Associates
Engineering and Environmental Services

Prepared for:
U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland

Sierra Army Depot, Lassen County, California

Figure 1.1

Site Locations



Prepared for:
U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland

Sierra Army Depot, Lassen County, California

Figure 1.2

Sierra Army Depot Location Map

Harding Lawson Associates
Engineering and
Environmental Services

Geologic Age			Geologic Formation		Stratigraphy	Approximate Thickness in Meters	Physical Characteristics	Water-bearing Characteristics
Cenozoic	Quaternary	Recent	Sand Deposits		Qs	0-8	**Qsd:** Loose, wind-blown sand.	Highly permeable but located above water table, hence, contains little water.
			Lake Deposits		Ql	0-8	**Ql:** Unconsolidated silt and clay. Contains alkali.	Very low permeability and of little importance to groundwater.
			Basin Deposits		Qb	0-16	**Qb:** Unconsolidated sand, silt, and clay. Often contains alkali.	Low permeability. May yield small amounts of water to domestic wells.
			Intermediate Alluvium		Qal	0-30	**Qal:** Unconsolidated sand, silt, and gravel with lenses of clay.	Moderate permeability. Yields small to moderate quantities of water to wells.
			Landslides		Qls	0-16	**Qls:** Unconsolidated mixtures of rock, sand, and clay.	Moderate permeability. May yield moderate quantities of water to wells in Hidden Valley.
			Alluvial Fans		Qf	0-100	**Qf:** Unconsolidated gravel, sand, and silt, with some clay lenses.	Moderate to high permeability. Yields large quantities of water to wells. May contain confined water.
		Pleistocene	Near-shore Deposits		Qps	0-120	**Qps:** Unconsolidated, poorly cemented, bedded gravel, sand, and silt.	Highly permeable. Frequently occurs above water table. Where saturated, yields large quantities of water to wells and sumps.
			Lahontan Lake Deposits		Qpl	0-210	**Qpl:** Poorly consolidated bedded sand, silt, and clay.	Permeability ranges low to high. Contains important aquifers in Honey Lake Valley. Often yields large quantities of water to wells.
				Pleistocene Volcanic Rocks: Basalt	Qpvb	16-160	**Qpvb:** Jointed basalt flows containing zones of acoria.	Moderate to high permeability. May yield large quantities of water to wells. Acts as forebay for groundwater recharge.
				Pleistocene Volcanic Rocks: Pyroclastics	Qpvp	0-60	**Qpvp:** Bedded mudflows and tuffs.	Low permeability, unimportant to groundwater.
	Tertiary	Plio-Pleistocene		Plio-Pleistocene Volcanic Rocks: Basalt	TQvb	1200	**TQvb:** Jointed, fractured flows of vesicular basalt with some pyroclastic rocks.	Moderate permeability. May yield moderate amounts of water to wells. May contain confined water. Important as forebay for groundwater recharge.
				Plio-Pleistocene Volcanic Rocks: Pyroclastic Rocks	TQvp	?	**TQvp:** Pale-colored bedded tuff.	Unimportant to groundwater.
		Pliocene	Pliocene Lake Deposits		Tpl	0-1500	**Tpl:** Bedded, consolidated sandstone, tuffaceous siltstone, and diatomite.	Generally of low permeability. Locally may yield moderate quantities of water to wells. Contains confined water.
			Pliocene Pyroclastic Rocks		Tpvp	300	**Tpvp:** Massive, cemented tuff and mudflows.	Essentially impermeable.
		Pre-Pliocene		Sierran Volcanic Rocks: Basalt	Tsvb	600	**Tsvb, Tsva, Tsvp, Tsv:** Flows of fractured basalt, andesite, and minor amounts of other types of lava. Massive mudflows and tuffs.	Permeability ranges from poor to moderate. Basalt is generally above zone of saturation, is underlain by impermeable rock, and is unimportant to groundwater. A few areas may contain perched groundwater. Andesite and pyroclastic rocks are essentially impermeable.
				Sierran Volcanic Rocks: Andesite	Tsva / Tsv			
				Sierran Volcanic Rocks: Pyroclastic Rocks	Tsvp			
			Auriferous Gravels		Teg	?	**Teg:** Semi-consolidated gravel, sand, and clay.	Low to moderate permeability. Yields water to many springs. Not important to groundwater in Honey Lake Valley.
			Gold Rum Sandstone		Tgs	?		
			Fort Sage Sandstone		Tfs	?	**Tys:** Semi-consolidated, poorly cemented sandstone and shale.	Low permeability. May yield small quantities of groundwater to wells.
							Tfs: Consolidated, cemented sandstone.	Essentially impermeable.
Mesozoic	Jurassic to Cretaceous	Basement Complex	Granitic Rocks		JKgr	?	**JKgr:** Massive, poorly jointed diorite. Locally weathered and decomposed.	Impermeable where fresh. Decomposed rock may yield small quantities of water to wells and sumps.

Sources: State of California, Department of Water Resources, 1963; ESE, 1983

Harding Lawson Associates
Engineering and Environmental Services

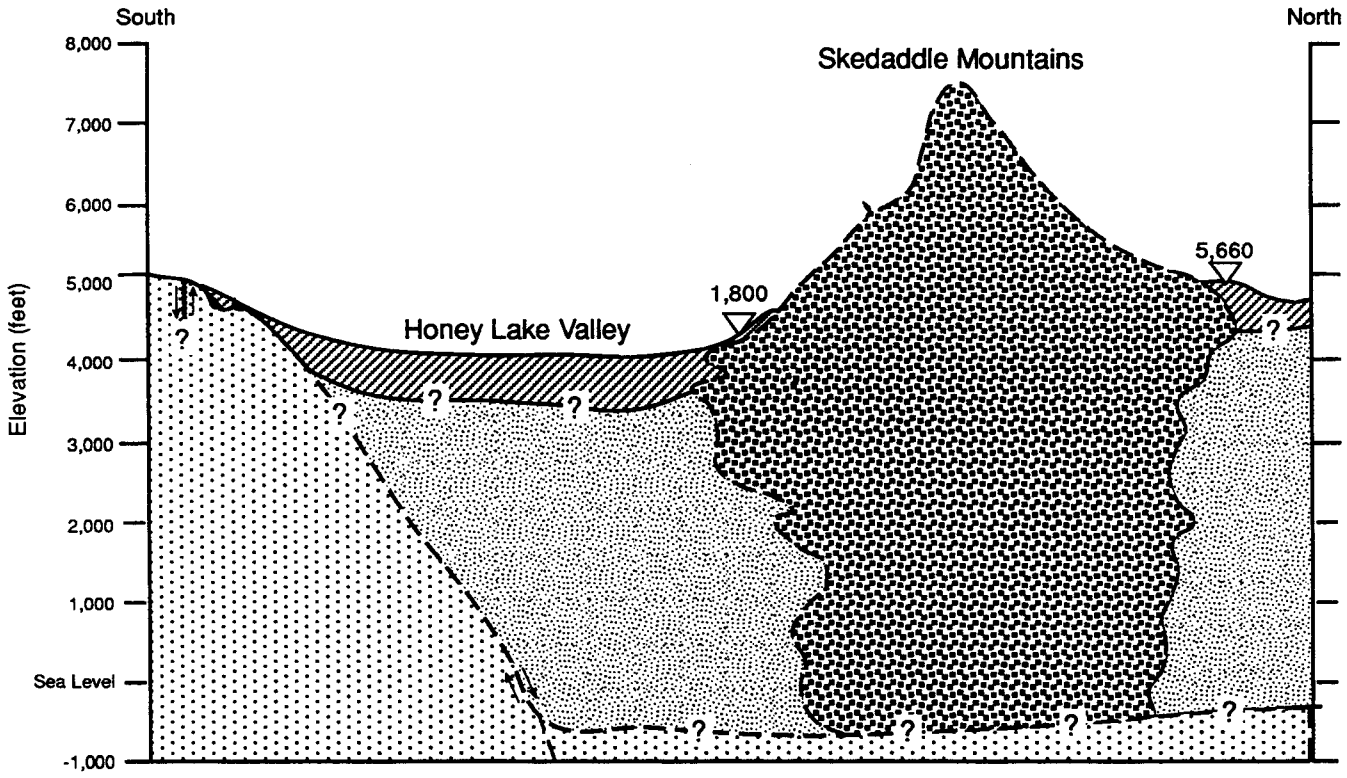
HLA

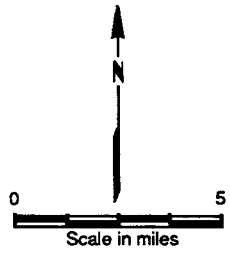
Prepared for:
U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland

Sierra Army Depot, Lassen County, California

Figure 1.3

Geologic Formations in Honey Lake Valley





Explanation

- Holocene and Pleistocene basin - fill sedimentary deposits
- Pliocene sedimentary and pyroclastic deposits
- Miocene to Oligocene volcanic rocks
- Cretaceous granitic bedrock
- Contact - queried where uncertain
- ? Fault - dashed where inferred, queried where uncertain. Arrows indicate relative direction of movement
- 5,660 Telluric sounding - number indicates thickness of volcanic unit, in feet

Source: Handman et al., 1990.

Harding Lawson Associates
Engineering and
Environmental Services

Prepared for:
U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland

Sierra Army Depot, Lassen County, California

Figure 1.4

Geologic Cross Section Through
Honey Lake Valley